Detecting coronary calcification with electron beam computed tomography: its role in managing coronary artery disease

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Electron beam computed tomography is a sensitive technique that detects and quantifies the extent of coronary atherosclerosis by imaging coronary calcification. In comparison with other techniques such as angiography, electron beam computed tomography can detect both early and advanced coronary atherosclerosis.

METHODS

The literature for this review was identified using the MEDLINE database (1966-1999) and bibliographies of existing literature.

CASE PRESENTATION

A 59-year-old white man was referred for cardiovascular screening prior to starting an exercise program. He had no history of coronary artery disease or cardiovascular symptoms, took no medications regularly, and was a nonsmoker. Past medical history was notable for borderline hypertension, and an abnormal lipid panel. His physical examination was notable for a blood pressure of 135/89 mm Hg. Laboratory testing revealed a fasting serum cholesterol level of 179, low density lipoprotein (LDL) cholesterol level of 83, and high density lipoprotein (HDL) cholesterol level of 21. A 12-lead electrocardiogram was normal.Electron beam computed tomography was recommended because of his cardiovascular risk factors. This study showed extensive calcifications in the right coronary artery, left anterior descending artery and a total calcium score (Agatston method) of 1101 (Figure 1). An exercise test with myocardial perfusion imaging was performed, during which the patient exercised to 15 minutes on a Bruce protocol. The perfusion images were normal. When

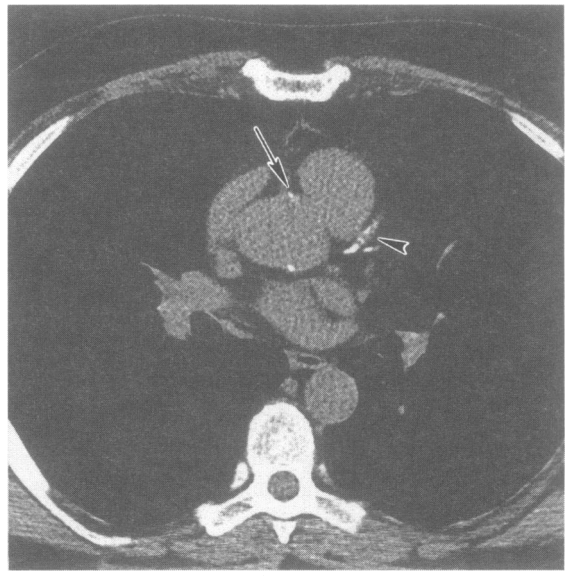

Figure 1 Electron beam computed tomographic scan showing calcification in the mid-portion of the left anterior descending coronary artery (arrowhead) and ostium of the right coronary artery (arrow)

further serologic studies were conducted, including lipoprotein (a) and small dense low density lipoprotein levels, results were within normal limits. An exception was the fasting serum homocysteine level, which was 15.2 ng/dL (abnormally high). The patient began a daily therapeutic regimen of 325 mg aspirin, 1 mg folate (for homocysteine reduction), 50 mg atenolol (for hypertension), and 40 mg pravastatin (to improve the LDL/HDL ratio). One year later, the patient's serum high density lipoprotein level had improved to 32 mg/dL, his blood pressure was 125/80 mm Hg, and he was asymptomatic during regular aerobic exercise.

Summary points

- Electron beam computed tomography accurately quantifies the presence and extent of coronary calcification.
- Coronary calcification always indicates the presence of atheromatous plaque. The prevalence of coronary calcification increases with age and is related to underlying cardiovascular risk factors.
- Coronary calcification identifies patients at an increased risk of cardiovascular events.
- Patients with coronary calcification should be considered for aggressive risk factor modification and preventive treatments such as beta blockers for silent ischemia, aspirin and drugs to lower cholesterol.

DISCUSSION

Electron beam computed tomography and coronary artery disease

Electron beam computed tomography produces electrocardiographically gated still-frame images of the heart, which are used to quantify the presence and extent of coronary calcification. The test is noninvasive, rapid, and costs between $400 and $500. There are only between 50 and 100 of these scanners in the United States; however, other types of computed tomography scanners (such as spiral computed tomography) may provide a reasonable alternative for coronary calcium detection. Based on the detection of discrete coronary calcifications in the epicardial coronary vessels, a calcium scoring system has been

developed and validated with pathologic studies by Agatston and colleagues.[1] The calcium score is a unitless measurement calculated as the product of the area of calcification (in mm^2) and the density score (each segment of detected calcium is rated on a scale from 1 to 4 based on the maximal computed tomography density in Hounsfield units). Typically, results from electron beam computed tomography are reported as a composite calcium score for the entire epicardial coronary system (range 0 - >1000). Any score above zero indicates the presence of coronary calcification.

Coronary calcification is always associated with atheromatous plaque. The prevalence of coronary calcification increases with age.[2] Calcium scores hold similar significance in men and women,[3] although for any given score, women tend to be approximately a decade older than men.[2] Coronary calcification is related to conventional coronary risk factors, although these risk factors explain only 40% of the variability of coronary calcification.[4]

Clinical uses

Asymptomatic populations

Acute ischemic coronary events arise most commonly from plaque rupture or erosion of mild, nonobstructive arterial stenoses. Plaque characteristics unrelated to the degree of stenosis, such as lipid content and thickness of the plaque fibrous cap, are better predictors of rupture than is the degree of obstruction.[5] Assuming that calcification is a sensitive marker for all atheromatous disease, regardless of the degree of obstruction, electron beam computed tomography can provide earlier detection of subclinical disease.

Preliminary evidence suggests that it may be a useful aid to predicting which asymptomatic patients are at risk for cardiovascular events.[6] But, whether coronary calcium is a better marker of cardiovascular risk than traditional risk factors is controversial. Nonetheless, because silent myocardial ischemia is an important predictor of prognosis, patients with a calcium score of 400 should be referred for stress imaging procedures.[7] Almost 50% of such patients will have abnormalities on myocardial perfusion studies, indicating the presence of myocardial ischemia. In most cases, these patients would be appropriate candidates for medications to suppress ischemia, for example with beta blockers,[8] to improve prognosis. An electron beam computed tomographic scan that yields no or few findings does not confer the complete absence of risk for cardiovascular events.[9]

We recommend limiting screening to men over the age of 40, and women over the age of 50, because of the low prevalence of calcification in younger men and women. Patients who are referred should have modifiable coronary risk factors, to optimize the therapeutic impact of the test.

Symptomatic patients

The presence and extent of coronary calcification is related to the severity coronary artery disease on angiography. Electron beam computed tomography has a sensitivity of 81% to 94% and a specificity of 72% to 86% for the diagnosis of any angiographic coronary artery disease.[10] For obstructive coronary artery disease (>50% stenosis of any epicardial vessel), the sensitivity and specificity are approximately 95% and 50%, respectively.[10,11] Thus, electron beam computed tomography may be used to rule out obstructive coronary artery disease in patients with atypical symptoms and a low to intermediate pre-test probability. A value of 123 for the coronary calcium score has been proposed as a cutoff at which the sensitivity and specificity for detection of a 70% stenosis is 82%.[11,12] False-negative studies may be more common in young patients due to the presence of early, noncalcified atherosclerosis.[13] The higher the calcium score, the greater the likelihood of obstructive coronary artery disease.[12] The accuracy of exercise testing, myocardial perfusion imaging, and electron beam computed tomography for the identification of patients with obstructive coronary artery disease are comparable.[14] But, because the inter-test agreement of these tests is limited, these methods are best considered complementary.

Potential impact on patients and physicians

Patients with traditional risk factors for cardiac disease should be treated using accepted efficacy endpoints (such as the National Cholesterol Education Program guidelines), regardless of the results of electron beam computed tomographic assessment. For patients with borderline risk factors, however, the finding of coronary calcification using this test may justify a more intensive approach to risk factor modification than is indicated by these guidelines.[15] Preliminary evidence suggests that an abnormal result from electron beam computed tomographic testing may create a teachable moment for patients.[15] For example, evidence of early atherosclerosis on electron beam computed tomographic scans could be used to motivate a smoker to stop smoking. While more evidence is needed,[16] it may become an important tool for targeting interventions and improving adherence to treatment recommendations in preventive cardiology.

Use for screening for cardiovascular disease

Overall, positive and negative results of electron beam computed tomography must be interpreted in light of the patient's age, and with the understanding that the implications of the test are probabilistic (Figure 2). Patients with no detectable calcification can generally be reassured that the test suggests a low probability of severe atherosclerosis and a low short-term (several years) risk of cardiovascular events. False-negative test results can occur,

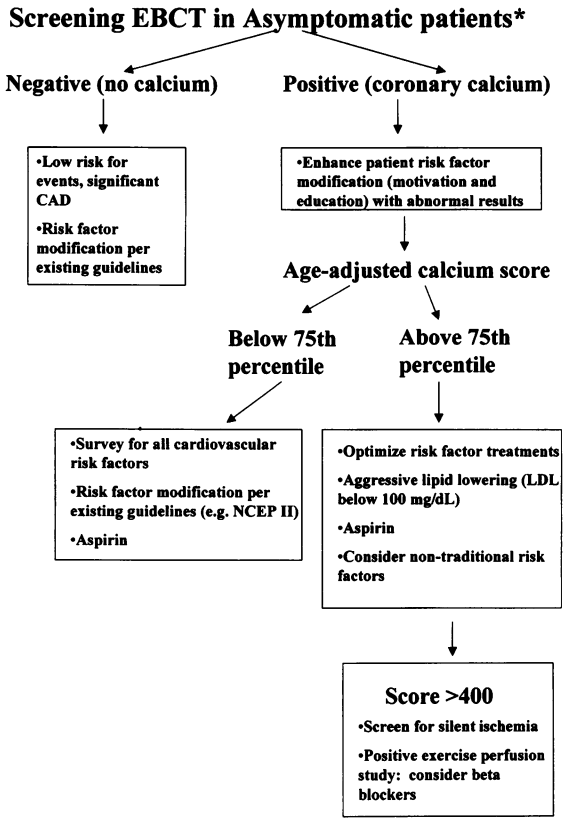

Figure 2 Flow diagram showing interaction between electron beam computed tomography results and clinical management.
Screening electron beam computed tomography population:

- Asymptomatic for coronary artery disease
- Age: men ≥40; women ≥50
- 1 or more cardiovascular risk factors

however. Thus, with a patient who has a high probability of coronary artery disease prior to the test, less confident statements about the nature of the results, and perhaps additional testing (for example, myocardial perfusion imaging) may be worth considering. In patients 40 years of age or younger, coronary calcification is less common, thus the diagnostic utility of a negative result is limited. For patients with negative findings, the strategies for risk factor modification should follow conventional guidelines for primary prevention.

Patients in whom scanning shows coronary calcification will often be anxious about the results. Counseling can be time consuming as patients must be educated about the atherosclerotic process and their coronary risk factors. The age of the patient is critical to determining how to counsel a patient about their risk of developing clinical manifestations of cardiovascular disease. Sedentary patients should undergo exercise stress testing prior to starting exercise programs. Patients with abnormal results of scans should be carefully examined for modifiable coronary risk factors. From the physician's perspective, the finding of any coronary calcification in a young patient or excessive (upper quartile relative to the patient's age) calcification may alter the medical approach to coronary risk. Considerations include prescribing aspirin and perhaps applying a lower threshold for initiating the use of drugs to lower cholesterol levels. For patients with few modifiable risk factors, further consideration of non-traditional risk factors (for example, homocysteine) or therapies (vitamin E) may be warranted.

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